ICO

# ROOFS

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**Introduction**
- Roof definition
- Design conditions

**Requirements: CTE Regulation**
**Classification: types of roof** (examples)
- According to its shape or slope
- According to its use
- According to the structural system
- According to its hygrothermal conditions
- According to the thermal insulation position

**Materials**
**Flat roof**
Types
Constructive details
Execution process
Flat roof and installations
**Pitched roof**
Types
Constructive details
Execution process
Pitched roof and installations

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# WHAT IS A ROOF?

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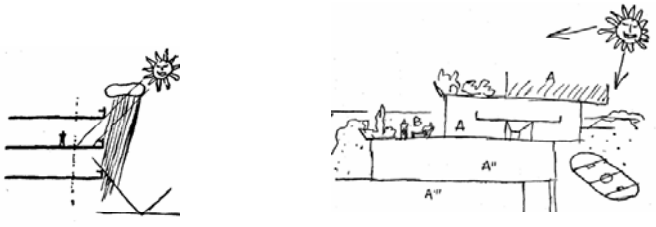
# DEFINITION



**WHAT IS A ROOF?:**

Set of constructive elements whose mission is to **protect** the upper part against environmental conditions and their actions.

- Meteorological phenomena (rain, snow, wind)
- Solar action (radiation and temperature variations).



Le Corbusier, sketches and studies for the housing project in Argel, 1933/34

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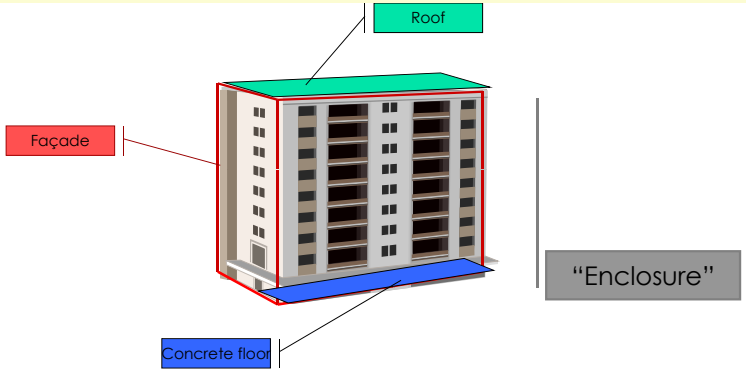
# Additional definitions



**According to the CTE the roof is one of the elements that compounds the *THERMAL ENCLOSURE* of the building**




**The CTE define the roof as:**

"an enclosure in contact with the exterior air on its upper side with a slope of less than 60° in relation to the horizontal"

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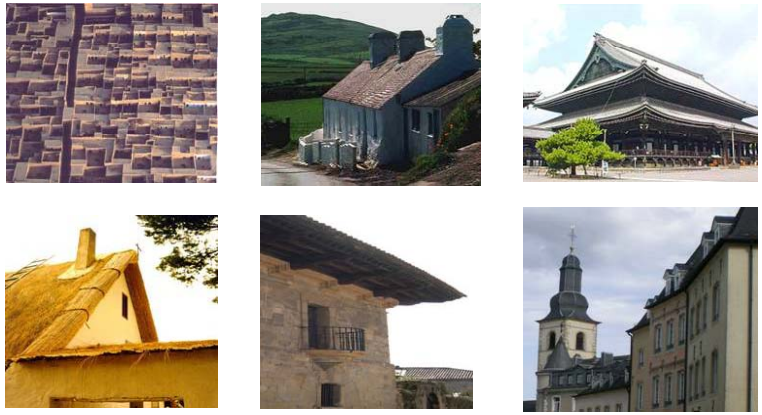
# ROOFS CONDITIONS



Depending on the climatic area, the roofs vary in slope, dimensions, materials,...acquiring different aesthetic and formal characteristics.



Traditional roofs : Tunisia, Great Britain, Kyoto, Valencia, Asturias and Luxembourg

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# The evolution of the roof…



Humanity has protected itself from environmental conditions through different constructions.

The roofs have evolved in these constructions, adapting, improving …

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València's historic centre

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## Evolution of the traditional roof versus the flat one

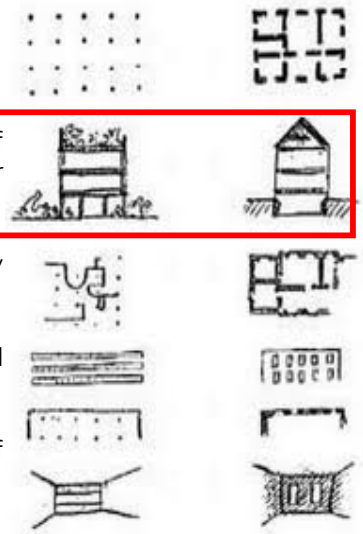
1. The **house on pillars** so that the ground is as free as a garden.

2. The **roof-garden** so that instead of pitched roofs, the terraces are just another garden.

3. The **free floor**, not rigidly distributed by fixed partitions walls.

4. The **continuous window**, developed horizontally.

5. The **free facade**, that is, independent of the supporting structure.



Le Corbusier, the five principles of modern architecture

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## Evolution of the traditional roof versus the flat one

Le Corbusier, Villa Fallet Roof, La Chaux de Fonds, Switzerland, 1905

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## Evolution of the traditional roof versus the flat one

Le Corbusier, roof of Ville Savoye, Poissy, France 1928

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# ICO DESIGN CONDITIONS

- 1) Environmental protection:
  - Waterproofing
  - Thermal insulation and hygrothermal control
  - Solar radiation protection
  - Acoustic insulation
  - Wind protection
- 2) Security :
  - Structural stability/ movements: dilatations
  - Prevent detachment of parts or elements
  - Burglary and robbery
  - Stability and fire protection
- 3) Durability
- 4) Aesthetic conditions

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# ICO REQUIREMENTS: REGULATION

CTE
Código Técnico de la Edificación

- Structure, stability DB-SE, Structural Code
- Hygrothermal conditions, DB-HE
- Fire protection DB-SI
- Acoustic conditions, DB-HR
- Materials Recognised Solutions, CE marked
- Tests, trials, mandatory and recommended

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# ICO Requirements: Regulation

CTE
Código Técnico de la Edificación

• Hygrothermal conditions, DB HE
**Thermal enclosure** of the building

- Conditioning and insulation.
- Thermal resistance/ U value,
- Condensations.
- Air permeability

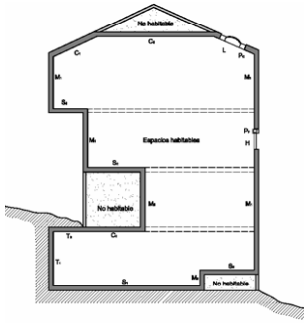


Figura 3.2 Esquema de *envolvente térmica* de un edificio

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# ICO Requirements: Regulation

CTE
Código Técnico de la Edificación

• Hygrothermal conditions, DB HE
**Thermal enclosure** of the building

Los parámetros característicos que definen la *envolvente térmica* se agrupan en los siguientes tipos:

a) transmitancia térmica de muros de fachada $U_M$;
b) transmitancia térmica de cubiertas $U_C$;
c) transmitancia térmica de suelos $U_S$;
d) transmitancia térmica de cerramientos en contacto con el terreno $U_T$;
e) transmitancia térmica de huecos $U_H$ ;
f) factor solar modificado de huecos $F_H$;
g) factor solar modificado de lucernarios $F_L$;
h) transmitancia térmica de medianerías $U_{MD}$.

DB HE art 2.1. apartado 3

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# ICO Requirements: Regulation "others"

CTE
Código Técnico de la Edificación

• Hygrothermal conditions, DB HE
**Thermal enclosure** of the building

•Solar contribution ACS > SOLAR PANELS
- Collection area, slope, …
- Number and arrangement of panels, orientation …
- Spaces for installations, pipe passages,…
- Surveillance and maintenance plan > ACCESSIBILITY

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## BASIC CLASSIFICATIONS OF ROOFS

**Shape and behaviour against water** (CTE DB-HS table 2.9 and 2.10)

- *Pitched roofs*, they "expel" the water by slope >15% (from 15-173% or 60º)
- *Flat roofs*, they "lead" the water towards its evacuation by waterproofing, sloping between 1-15%

**Use**

- *Passable roof*, used for other purposes, e.g. drying
- *Non-passable roofs*, only for maintenance

**Hygrothermal conditions**

- *Ventilated or cold roofs*, exterior/interior space ventilation.
- *Non-ventilated or warm roofs*, use thermal insulation.

**Thermal insulation position**

- *Traditional roofs*, insulation close to the interior side.
- *Inverted roofs*, insulation on the exterior side.

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**Pitched roof**
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- **According to its shape and behaviour against water**
  - Pitched roofs (slope from 15-173% or 60º)
    - Simples (monopitch, gable end roof, ...polyhedral)
    - Combination, complex,
    - Curved

  - Flat roof (slope from 1-15%)
    - Passable
    - Non passable (Gardened, flooded,...)

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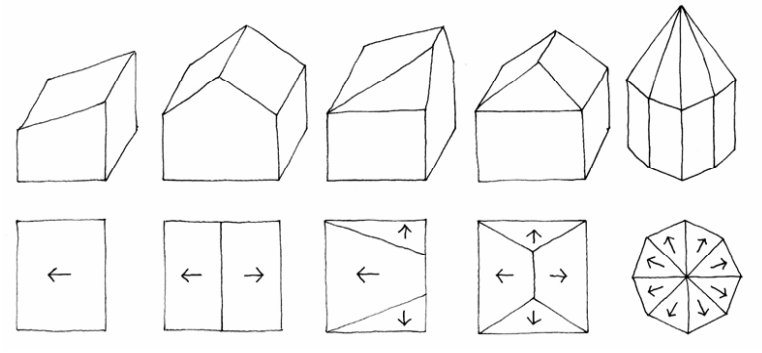
# TYPES OF ROOFS: shape and geometry



**Pitched roofs**

- **Simples**: monopitch, gable end, hipped end, polyhedral



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# Pitched roof (traditional)

Cathedral of Granada.

Pitched roof. Ceramic tile even pitch and glazed tile ridge

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# Pitched roof

Flat roof on the left, pitched gable and hipped in the centre photograph

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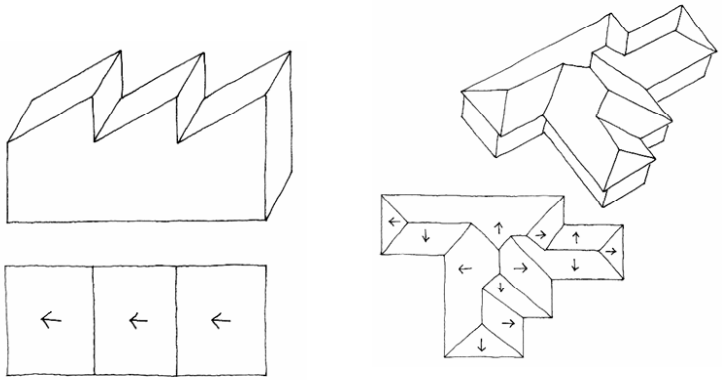
# TYPES OF ROOFS: shape and geometry



**Pitched roofs**

- Complex (e.g. sawtooth roof)
- Combinations



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## Pitched roof: Complex roofs

"Sawtooth" industrial pitched roof

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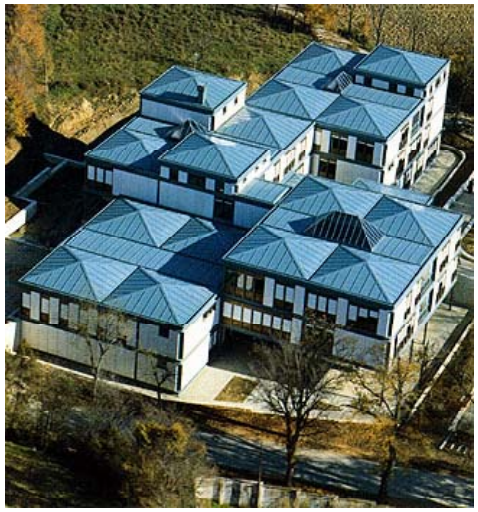
## Pitched roof: Combination roofs





Combination of different forms of roofing.

University of Navarra

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## Pitched roof: Combination roofs and domes

Central Market of Valencia. General view of the roofs and detail of the dome with the "Cotorra del Mercat" ending.

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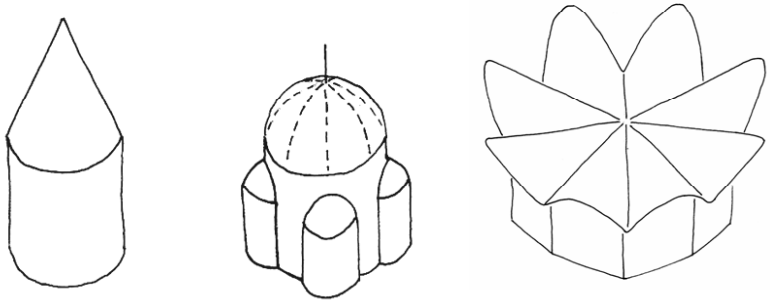
## TYPES OF ROOFS: shape and geometry



**Pitched roofs**

- **Curves**, rotational curves or revolution surfaces (complete or fragments thereof) conical, cylindrical, spherical, paraboloid, ... singular roofs



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## Pitched roof: Curve roofs, domes

Monastery of San Miguel de los Reyes, Valencia.

Several types of roofs. In the centre dome with restored lantern.

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## Pitched roof: Curve roofs, domes

Cathedral of Valencia.

Flat roofs and domes with glazed tiles in the side chapels

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## Pitched roof: Curve roofs

Concrete paraboloid roof, L' Oceanografic, Valencia. Felix Candela

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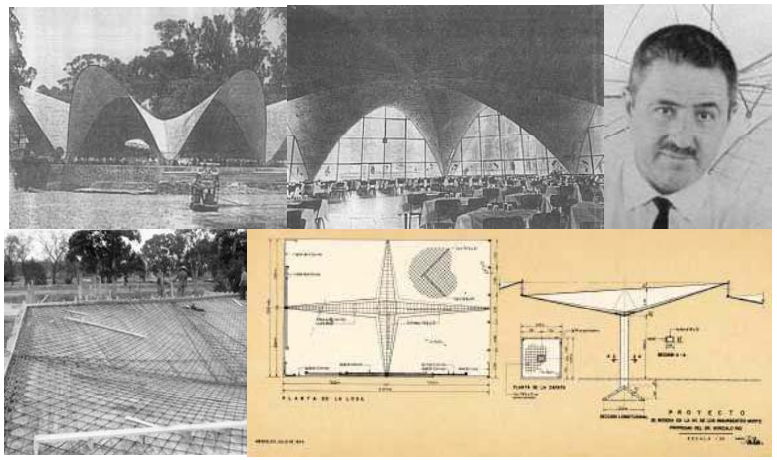
## Pitched roof: Curve roofs



Some works by Felix Candela, process of execution of the reinforced concrete "sheet" ("ruled surface"), plans.....

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## Pitched roof: Complex roofs

Prince Philip Museum, Architect Santiago Calatrava

Sheet metal roof

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## Pitched roof: Curve roofs

Glass and self-protecting metal roof.

Sciences City, Valencia. Santiago Calatrava

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## Pitched roof: Curve roofs

Renovation of the roof of the Santa Caterina Market, Barcelona

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## Pitched roof: Curve roofs

Project for the refurbishment and extension of Barajas Airport T4, Madrid. E. Lamela

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# Pitched roof

Stanstead Airport, London, architect Norman Foster. Integrated structure with installations and prefabricated panel roof.

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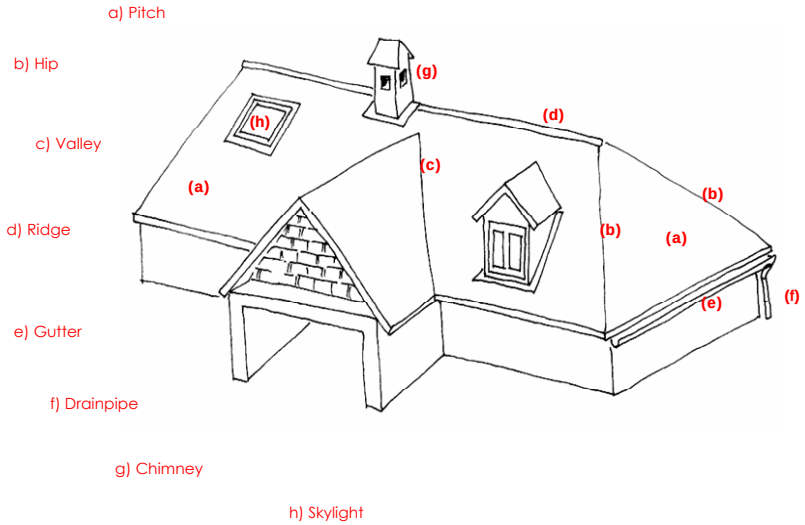
# Vocabulary: pitched roofs

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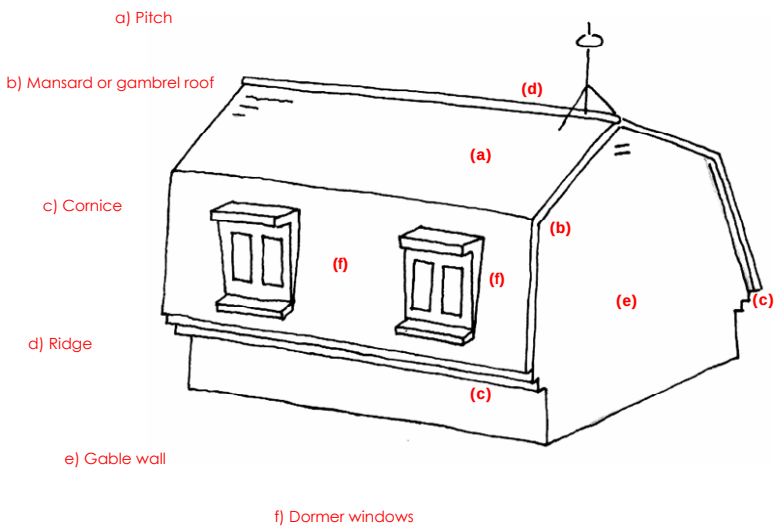
# Vocabulary: pitched roofs

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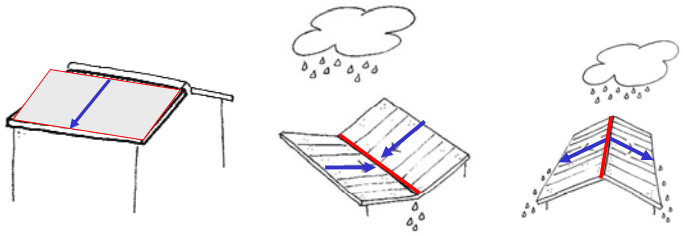
# Vocabulary: pitched roofs

- Pitch: Inclined plane that defines the roof.
- Intersection of two pitches.
  - Valley, in v-shaped (concave)
  - Hip in inverted v-shaped (convex)



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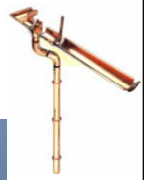
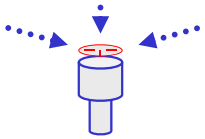
# ICO Vocabulary: pitched roofs

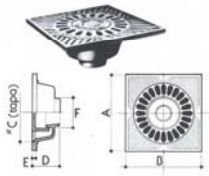
- Pitch: Roof pitch, as a % or in degrees

- Drain: Hollow where water is collected
- Gargoyle: small evacuation pipe to the exterior
- Gutter: rainwater collection system for a roof. It can be hidden or "box", and hanged or external



- Drain pipe: vertical pipe for water drainage





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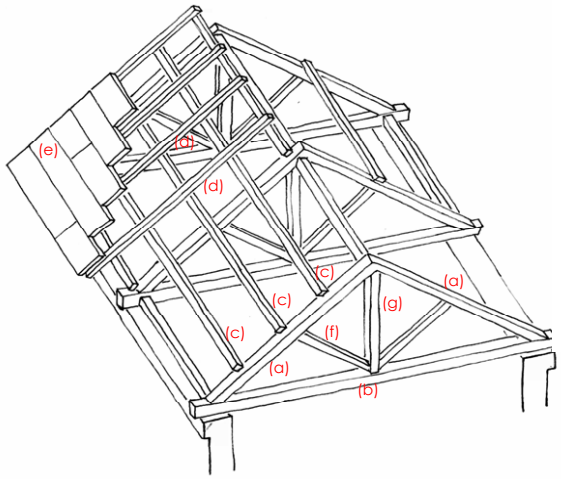
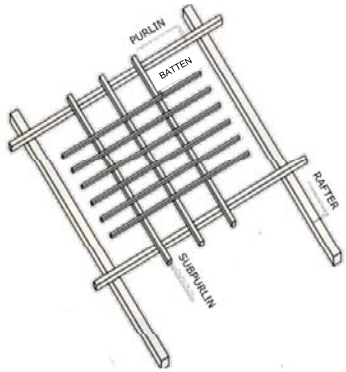
# ICO Vocabulary. Pitched roofs. Structural frames: trusses.




a) Rafter
b) Tie beam
c) Purlins
d) Subpurlin
e) Roof board
f) Raking shore
g) King post

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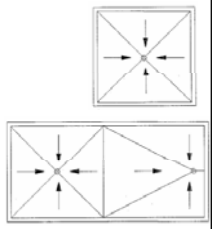
# ICO TYPES OF ROOFS: shape and geometry

**Flat roofs**

- Passable roofs



- Non-passable roofs

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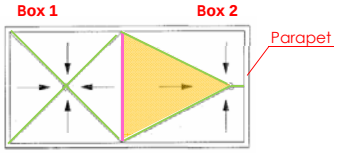
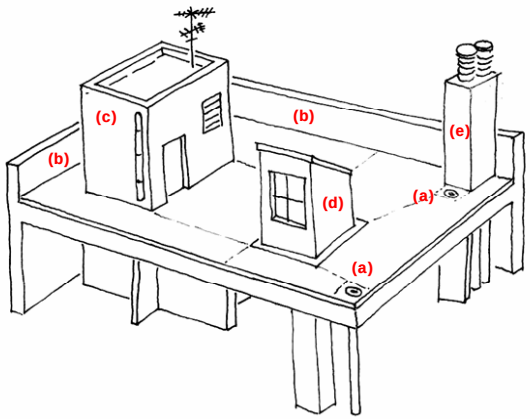
# ICO Vocabulary: flat roofs




Gable
Line of maximum slope
Hip
Valley
Drain




a) Drain
b) Parapet
c) Bulkhead
d) Roof-light
e) Ventilation pipe (shunt)

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# Flat roof. Elements.

**"Ventilated" flat roof**

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# Flat roof: Passable flat roof.

"Flashing" detail in a ventilated flat roof.

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# Flat roof: Non-passable flat roof.

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# Flat roof

City of Justice, Valencia, flat roof

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# ICO BASIC CLASSIFICATIONS OF ROOFS

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- *Pitched roofs*, they "expel" the water by slope >15% (from 15-173% or 60º)
- *Flat roofs*, they "lead" the water towards its evacuation by waterproofing, sloping between 1-15%

**Use**
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- *Non-passable roofs*, only for maintenance

**Hygrothermal conditions**
- *Ventilated or cold roofs*, exterior/interior space ventilation.
- *Non-ventilated or warm roofs*, use thermal insulation.

**Thermal insulation position**
- *Traditional roofs*, insulation close to the interior side.
- *Inverted roofs*, insulation on the exterior side.

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# ICO CLASSIFICATION

- **According to the use**

## Flat roofs

- Passable roofs (1-5%)… tiles.
- Non-passable roofs (1-15%)…gravel, flooded

## Pitched roofs

- Use of the space "below deck"
- With attics/lofts and mansard

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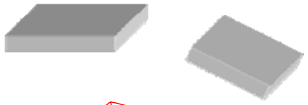
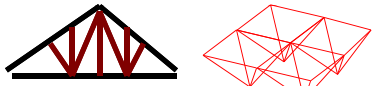
# ICO CLASSIFICATION

- **According to its structural system**

Slabs and floor slabs
- Flat (with slope formation)
- Inclined (without slope formation)

- Floor slabs or solid slabs
  - Horizontal(with flat or pitched roofs)
  - Inclined
- Frame systems
  - Trusses or frameworks
  - Spatial structures
- Structural surfaces
  - Vaults, domes.
  - Rotational curves or revolution surfaces





Horizontal floor slab and formation of slopes with lightweight partition walls

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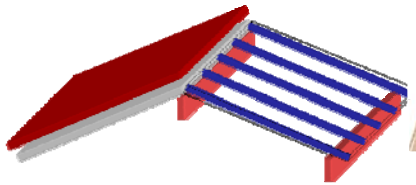
# ICO TYPES OF ROOFS: structural system

**Floor slabs or solid slabs**

- **Horizontal**

- **Inclined**



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# ICO Pitched roofs: structural system.

Horizontal floor slab and slope formation with lightweight partition walls

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# ICO Pitched roofs: structural system. Floor slab.

Horizontal floor slab and slope formation with lightweight partition walls

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## Pitched roofs: structural system.

Concrete floor slab on a pitched roof

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## Pitched roofs: structural system. Floor slab.

Pitched roof with inclined concrete floor slab.

Single-family house, Valencia

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## Pitched roofs: structural system.

Slope formation with concrete slab or floor slab

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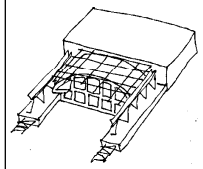
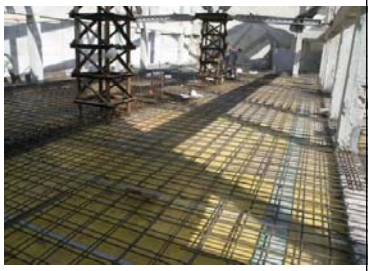
## Pitched roofs: structural system. Floor slab.

Solid slab





Slope formation with inclined floor slab or solid slab of concrete

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## ICO Roofs: structural system. Floor slab.

Valencia Conference Centre, Norman Foster.

Inclined floor slab made with prefabricated concrete panels and beams.

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## ICO Pitched roofs: structural system. **Frame system**.

Structural system made of wooden **TRUSSES**.

Interior roof of Plaza Redonda, Valencia

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## ICO Pitched roofs: structural system. **Frame system**.

Structural system made of Metallic **TRUSSES**.

Train Station, Xàtiva (Valencia)

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## ICO Pitched roofs: structural system. **Frame system**.

Warped surface by means of a **SPATIAL STRUCTURE** of triangulated curved beams

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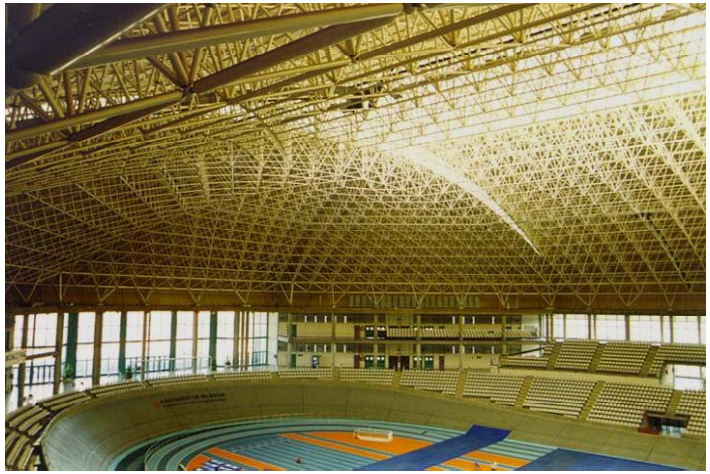
## Pitched roofs: structural system. **Frame system.**





Velodrome and Luis Puig Sports Pavilion in Valencia.

Pitched roof made of curved tubular **SPATIAL STRUCTURE**.

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## Pitched roofs: structural system. **Frame system.**

Pitched roof made of wooden **FRAMEWORK** structure

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## Pitched roofs: structural system.

Arcos diafragma, Iglesia de San Domenech, Xàtiva

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## Pitched roofs: structural system. **Frame system.**

Front tile

Pitched roof made of wooden **FRAMEWORK** and roof board.

Interior view of wooden roof with ceramic roof board

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# ICO Pitched roofs: structural system. **Frame system.**

Pitched roof made of wooden **FRAMEWORK** and roof board.

Interior view of wooden roof with ceramic roof board

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# ICO Pitched roofs: structural system. **Frame system.**

Pitched roof made of wooden **FRAMEWORK** and roof board.

Interior view of wooden roof with ceramic roof board

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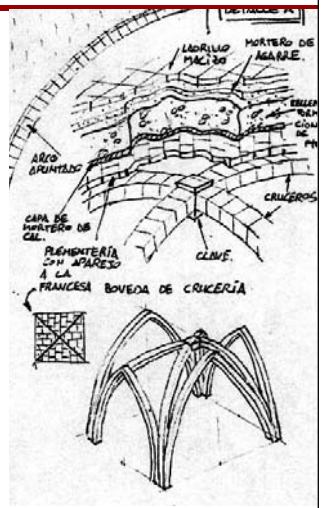
# ICO Pitched roofs: structural system. **Structural surfaces.**




**VAULT** as structural system.

El Salvador church, Burriana (Castellón)

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# ICO Pitched roofs: structural system. **Structural surfaces.**

**DOME** as structural system.

Escuelas Pías (Valencia)

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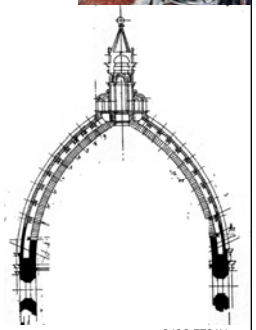
# ICO Pitched roofs: structural system. **Structural surfaces.**



**DOME** as structural system.

Santa María de Fiore, Firenze (Italy)

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# ICO Pitched roofs: structural system. **Structural surfaces.**

**REVOLUTION SURFACES** as structural system.

Oceanografic (Valencia)

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- Flat roof and installations

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- Pitched roof and installations

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# ICO BASIC CLASSIFICATIONS OF ROOFS

**Shape and behaviour against water** (CTE DB-HS table 2.9 and 2.10)

- *Pitched roofs*, they "expel" the water by slope >15% (from 15-173% or 60º)
- *Flat roofs*, they "lead" the water towards its evacuation by waterproofing, sloping between 1-15%

**Use**

- *Passable roof,* used for other purposes, e.g. drying
- *Non-passable roofs*, only for maintenance

**Hygrothermal conditions**

- *Ventilated or cold roofs,* exterior/interior space ventilation.
- *Non-ventilated or warm roofs*, use thermal insulation.

**Thermal insulation position**

- *Traditional roofs,* insulation close to the interior side.
- *Inverted roofs*, insulation on the exterior side.

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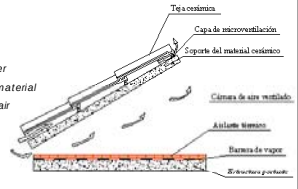
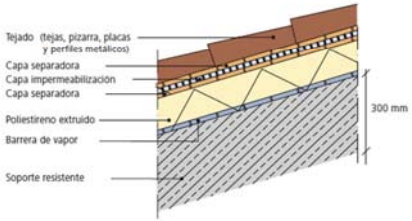
## According to the hygrothermal condition

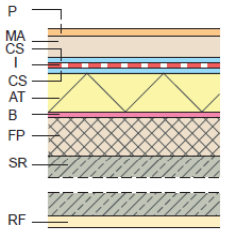
- Ventilated or cold roofs (2 leafs)
  - With ventilated air gap

| | |
|---|---|
| Teja cerámica | *Ceramic tile* |
| Capa microventilación | *Micro-ventilation layer* |
| Soporte del material cerámico | *Support of ceramic material* |
| Cámara de aire ventilada | *Ventilated air gap / air chamber* |
| Aislante térmico | *Thermal insulation* |
| Barrera de vapor | *Vapour barrier* |
| Estructura portante | *Supporting structure* |




- Non-ventilated or warm roofs
  - Con cámara de aire sin ventilar (2 hojas)
  - Sin cámara de aire (1 hoja)

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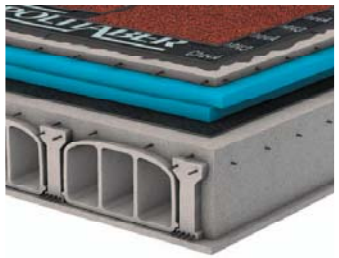
## According to the thermal insulation position

**Conventional** roofs

Waterproofing layer
Thermal insulation
Vapour barrier



"**Inverted**" roofs

Thermal insulation
Waterproofing layer

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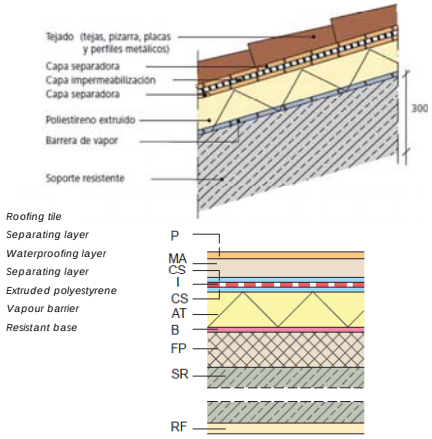
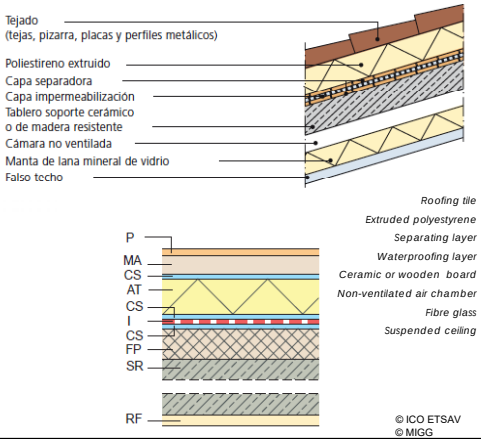
- **According to the thermal insulation position**

**Conventional** roofs




"**Inverted**" roofs

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**COVERING MATERIAL**

- **According to the exterior sheathing**
  - Of continuous materials
    - Natural elements: Straw, earth, ...
    - Plates of different materials: zinc, copper, polycarbonate
    - Bituminous materials (sheets or large format rolls)
    - Synthetic materials applied in mass, emulsion, …
  - Of discontinuous materials ("pieces")
    - Wood
    - Natural stones
    - Roof tiles
    - Tiles
    - Prefabricated
    - Bituminous (small size)
    - Glass

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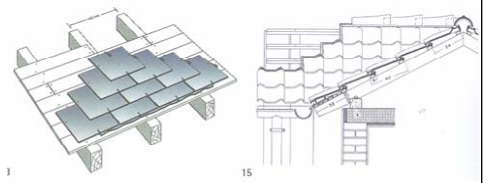
- Sheathing pieces:
  - Roof tiles: They are small pieces that are arranged and placed together or with overlaps

Types: curve (or arabic, or ceramic tile), flat, mix.



- They have different shapes and can be made of:
  - Stone materials: slates, ...
  - Ceramics, they can have surface treatment (glazing)
  - Special concrete
  - Metallic pieces

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## Elements and materials

Slate

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## Elements and materials

Concrete

**Asphaltic panels**

**Polycarbonate**

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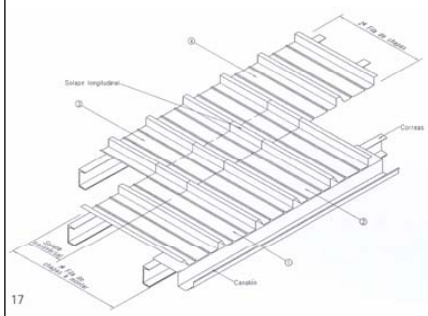
## Elements and materials



- Roof pieces:
  - Plates: They are large elements generally flat, corrugated or wavy so that they have more rigidity.



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## Elements and materials



- **Insulating materials:** Fiberglass, polystyrene, polyurethane,...

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## Elements and materials



- **Insulating materials:** rockwool

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## Elements and materials

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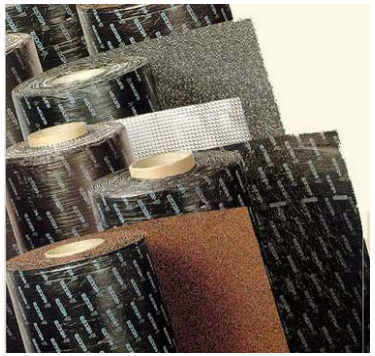
### Waterproofings and synthetic elements:

-Sheets or membranes: manufactured in the form of a roll, they are stretched and given continuity by the application of heat or adhesives

- Plastic elements PVC sheets, EPDM (ethylene propylene rubber)



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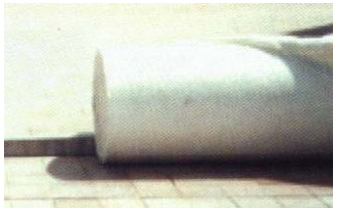
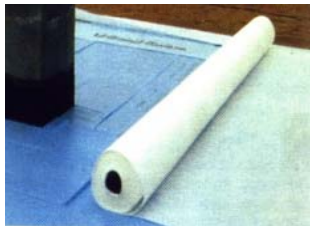
**Separating materials:** Polyester, geotextile, polyethylene





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- According to the thermal insulation position

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Types
Constructive details
Execution process
Flat roof and installations
**Pitched roof**
Types
Constructive details
Execution process
Pitched roof and installations

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## Flat roofs

Passable roofs (1-5%)… tiles.
Non-passable (1-15%)… gravel, fooded

## Pitched roofs

Use of the space "under roof"
With attic or mansards

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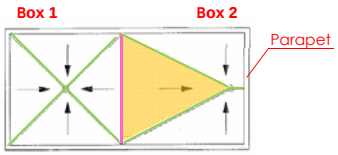
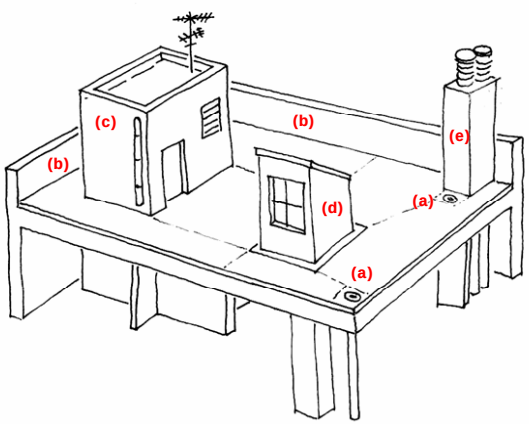
## Vocabulary: flat roofs




Gable
Line of maximum slope
Hip
Valley
Drain




a) Drain
b) Parapet
c) Bulkhead
d) Roof-light
e) Ventilation pipe (shunt)

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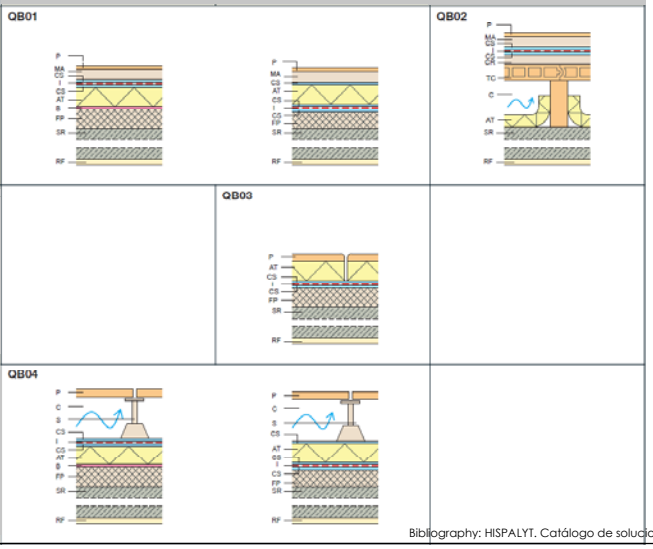
# ICO Types of flat roofs

**PASSABLE**

| | Non-ventilated or with air gap without ventilation – Conventional | Non-ventilated or with air gap without ventilation – Inverted | Ventilated – Conventional |
|---|---|---|---|
| Permanent paving | QB01 | | QB02 |
| Floating paving – with insulation | | QB03 | |
| Floating paving – on supports | QB04 | | |



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CR = Leveling layer
TC = Ceramic board
C = Chamber
I = Waterproofing
AT = Thermal insulation
B = Vapour barrier
FP = Slope formation
SR = Resistant support
RF = Underside coating
CF = Filtering layer
CD = Draining layer
S = Supports (plots)

Bibliography: HISPALYT. Catálogo de soluciones cerámicas

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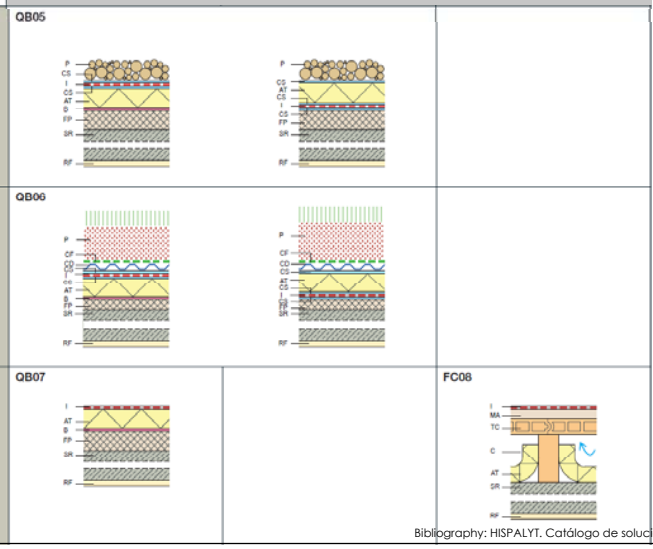
# ICO Types of flat roofs

**NON-PASSABLE**

| | Non-ventilated or with air gap without ventilation – Conventional | Non-ventilated or with air gap without ventilation – Inverted | Ventilated – Conventional |
|---|---|---|---|
| Gravel | QB05 | | |
| Gardened | QB06 | | |
| Self-protected | QB07 | | FC08 |



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|---|---|---|---|
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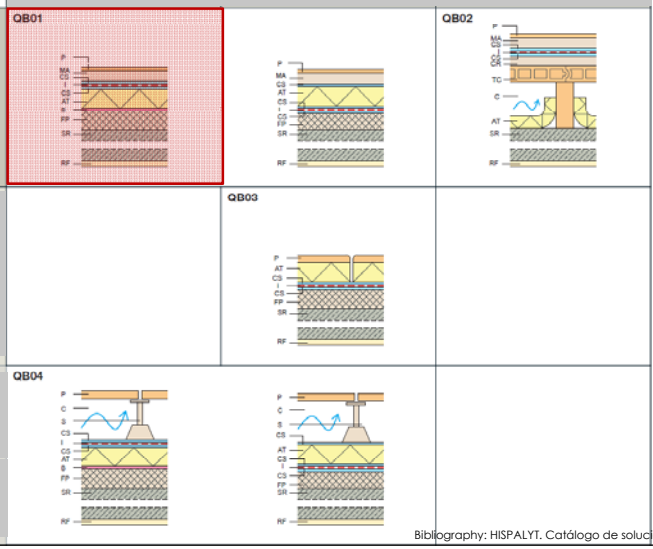

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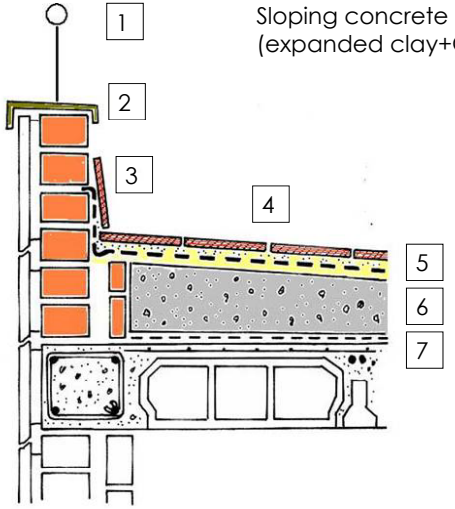
# ICO Permanent paving flat roofs. Warm (non-ventilated.)




Cellular concrete
Sloping concrete
(expanded clay+CM)

**Standard/type detail. Section.**
Flat roof, passable, non-ventilated, warm

1) Railing and handrailing
2) Parapet (acroterion)
3) Skirting board
4) Flooring, paving
5) Waterproofing layer
6) Insulating lightweight concrete
7) Vapour barrier

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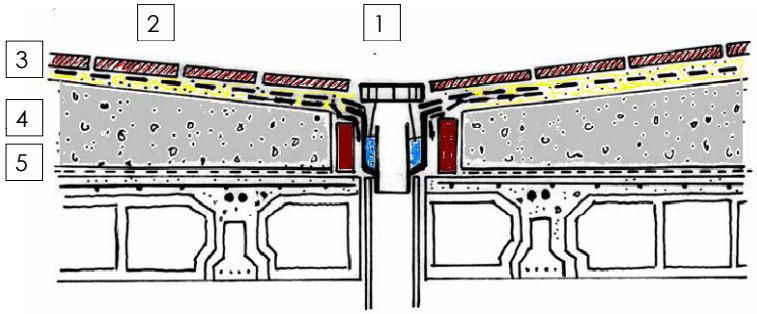
# ICO Constructive details. Flat roofs.

Warm or non-ventilated flat roof, passable. **Detail of meeting with drain**




1) Drain
2) Flooring(paving)
3) Waterproofing layer
4) Lightweight sloping concrete (with insulation properties)
5) Vapour barrier

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# ICO Constructive details. Flat roofs.

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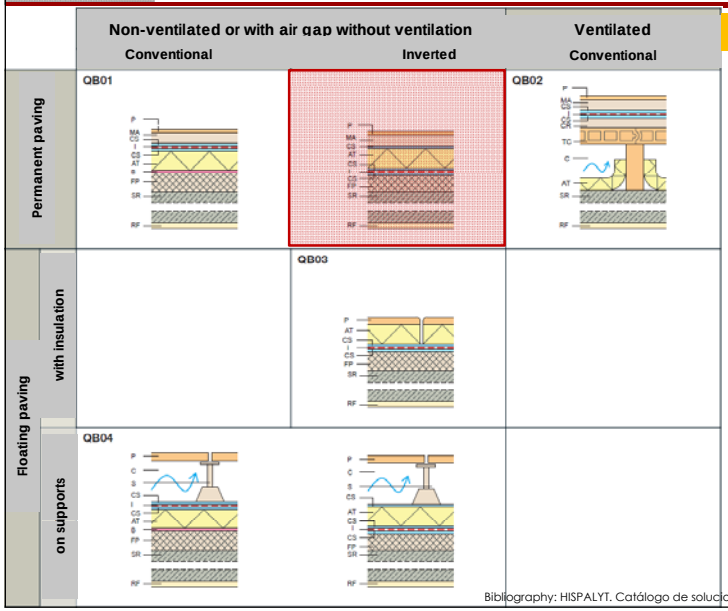
# ICO Types of flat roofs




P = Protection (finishing)
MA = Mortar
CS = Separating layer
CR = Leveling layer
TC = Ceramic board
C = Chamber
I = Waterproofing
AT = Thermal insulation
B = Vapour barrier
FP = Slope formation
SR = Resistant support
RF = Underside coating
CF = Filtering layer
CD = Draining layer
S = Supports (plots)

Bibliography: HISPALYT. Catálogo de soluciones cerámicas

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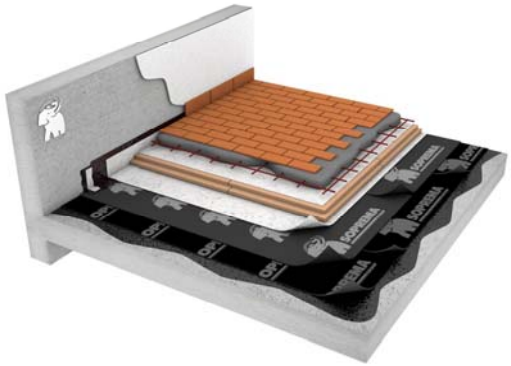
# Constructive details. Flat roofs.



## INVERTED AND NON-VENTILATED FLAT ROOF



**INVERTED ROOF**

**Resistant base**

1. **Slope formation**
2. **Waterproofing**
3. **geotextile**
4. **Thermal insulation**
5. **geotextile**
6. **finishing**

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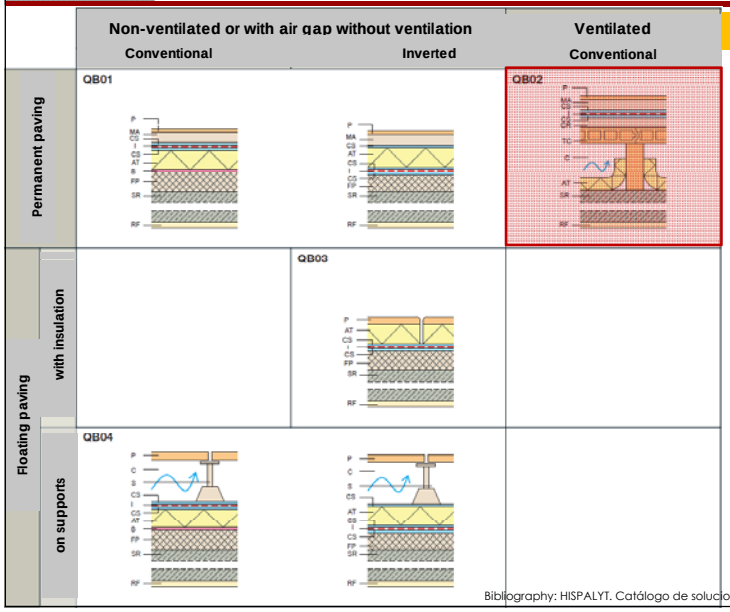
# Types of flat roofs






**PASSABLE**

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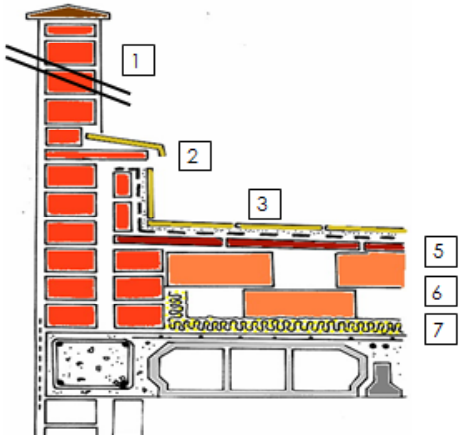
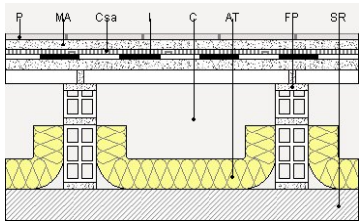
# PERMANENT PAVING FLAT ROOFS. Cold (ventilated)



## VENTILATED FLAT ROOF




| | |
|---|---|
| 1. Antepecho | *1. Parapet* |
| 2. Mimbel | *2. Flashing* |
| 3. Revestimiento pavimento | *3. Tiling cladding* |
| 4. Lámina impermeable | *4. Waterproofing layer* |
| 5. Tablero | *5. Board* |
| 6. Tabiquillos | *6. Lightweight partition walls* |
| 7. Aislamiento térmico | *7. Thermal insulation* |

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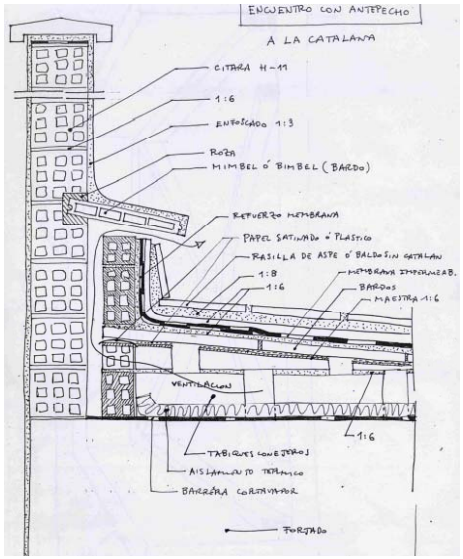
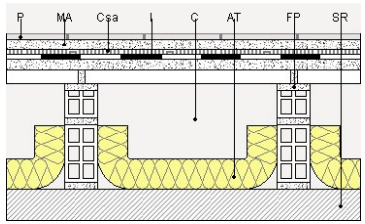
# PERMANENT PAVING FLAT ROOFS. Cold (ventilated)






**Standard/type detail. Section.**
Flat roof, passable, ventilated with lightweight partitions walls

| | |
|---|---|
| Encuentro con antepecho | *Meet ing with parapet* |
| A la catalana | *Catalan style (flat roof)* |
| Citara | *Half-brick wall* |
| Enfoscado 1:3 | *Rendering (cement mortar 1:3)* |
| Roza | *Notch* |
| Mimbel ó bimbel | *Flashing* |
| Refuerzo membrana | *Membrane reinforcement* |
| Papel satinado ó plástico | *Satin paper or plastic* |
| Rasilla de Aspe ó baldosín catalán | *Aspe tile or Catalan floor tile* |
| Membrana impermeabilizante | *Waterproofing membrane* |
| Bardos | *Large hollow brick* |
| Maestra 1:6 | *Screed rod (cement mortar 1:6)* |
| Ventilación | *Ventilation* |
| Tabiques conejeros | *Lightweight partitions walls* |
| Aislamiento térmico | *Thermal insulation* |
| Barrera cortavapor | *Vapour barrier* |
| Forjado | *Floor slab* |

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# ICO Permanent paving flat roofs. Cold (ventilated)

**Passable roof?**

**Cold roof?**

**Inverted roof?**

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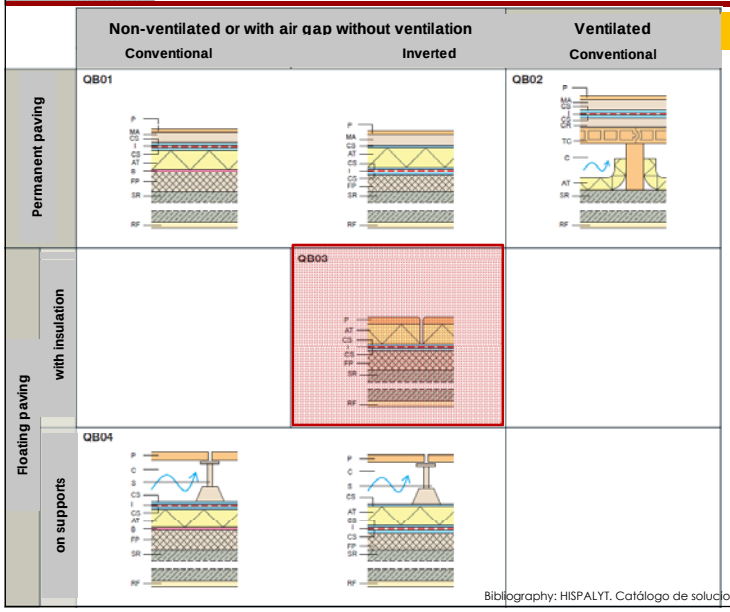
# ICO Types of flat roofs




**PASSABLE**

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C = Chamber
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B = Vapour barrier
FP = Slope formation
SR = Resistant support
RF = Underside coating
CF = Filtering layer
CD = Draining layer
S = Supports (plots)

Bibliography: HISPALYT. Catálogo de soluciones cerámicas

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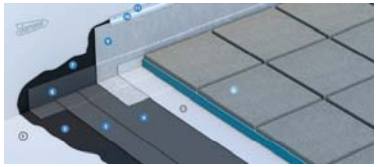
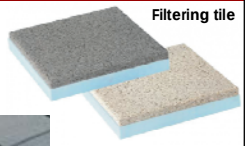
# ICO FLOATING PAVING ROOFS. With insulation



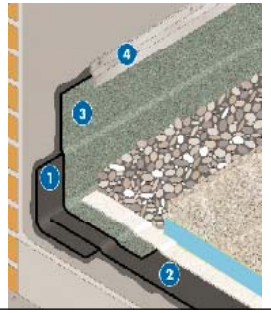


Filtering tile

**Passable roof?**

**Cold roof?**

**Inverted roof?**



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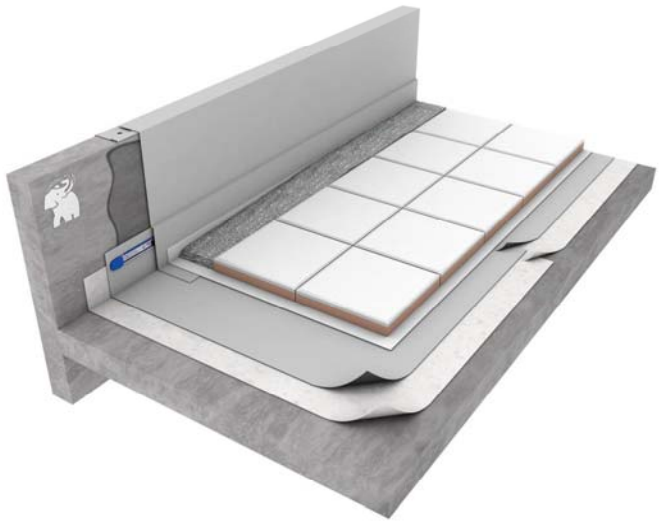
# ICO FLOATING PAVING ROOFS. With insulation



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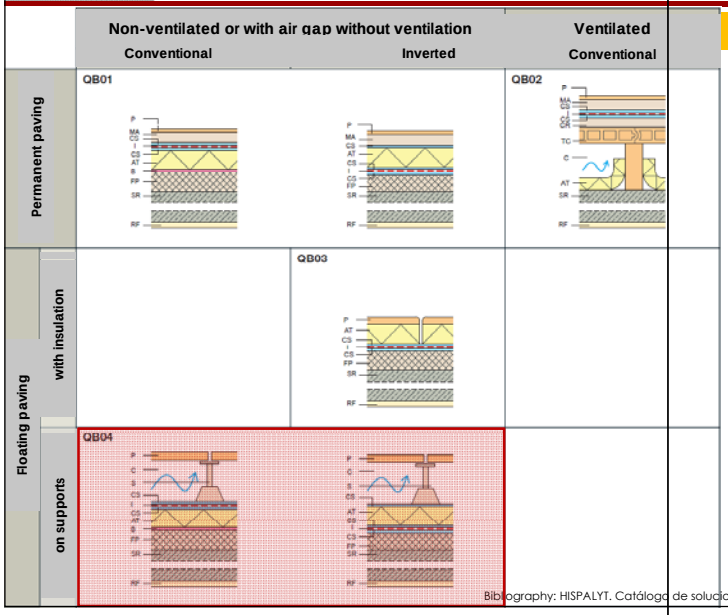
# ICO Types of flat roofs

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CD = Draining layer
S = Supports (plots)

Bibliography: HISPALYT. Catálogo de soluciones cerámicas

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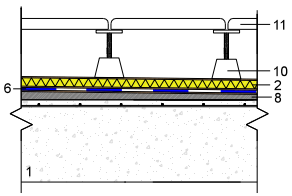
# ICO FLOATING PAVING ROOFS. On supports



Marqués de Valdecilla Hospital, Santander, "floating floor" made of slate

**Passable roof?** **Cold roof?** **Inverted roof?**

Floating paving are made up of **reinforced tiles** that are reinforced on the back side (the reinforced reinforcement increases safety of use by preventing it from breaking into pieces when the tile is accidentally broken), and that rest on supports that leave an empty space between the tile and the lower base either for the passage of pipes, or for the evacuation of rain water or water that has been used to clean the floor.

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# ICO FLOATING PAVING ROOFS. On supports

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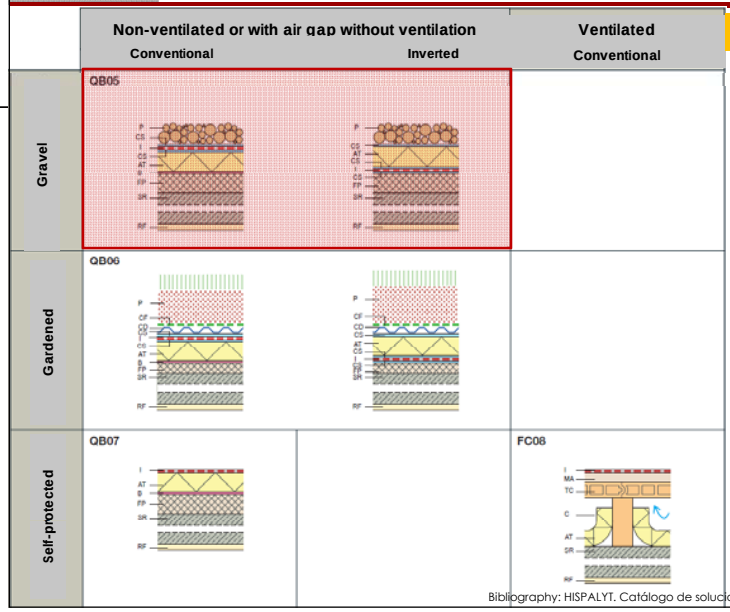
# ICO Types of flat roofs




**NON-PASSABLE**

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MA = Mortar
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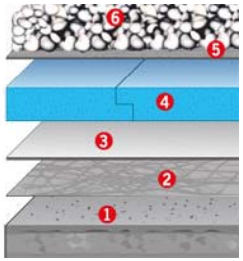
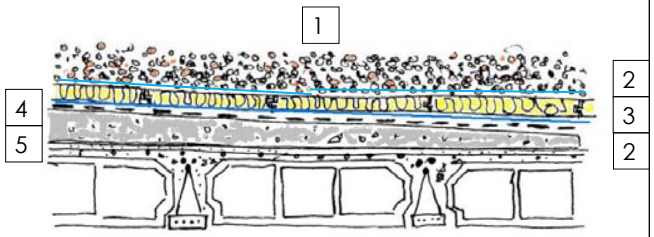
# ICO GRAVEL FLAT ROOF




**"Inverted" flat roof**. Standard/type section

**Continuous sheathing/protection?**




6) Protection and finishing: gravel
5) Separating layer: geotextile
4) Thermal insulation
3) Separating layer: geotextile
2) Waterproofing layer
1) Sloping concrete
0) Resistant support

1) Protection and finishing: gravel
2) Separating layer: geotextile
3) Thermal insulation
4) Waterproofing layer
5) Sloping concrete

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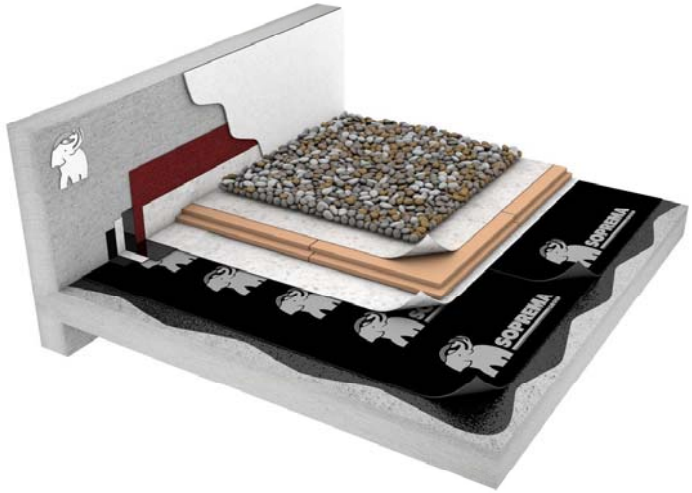
# ICO GRAVEL FLAT ROOF

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# ICO FLAT ROOF WITH GRAVEL AS PROTECTION AND FINISHING

- **finishing / protection**
- **geotextile (pointed protection)**
- **waterproofing**
- **geotextile**
- **thermal insulation**
- **vapour barrier**
- **slope formation**
- **resistant support**

**Passable roof?**

**Cold roof?**

**Inverted roof?**

- **finishing**
- **geotextile (filtering and pointed protection)**
- **thermal insulation**
- **geotextile**
- **waterproofing**
- **slope formation**
- **resistant support**

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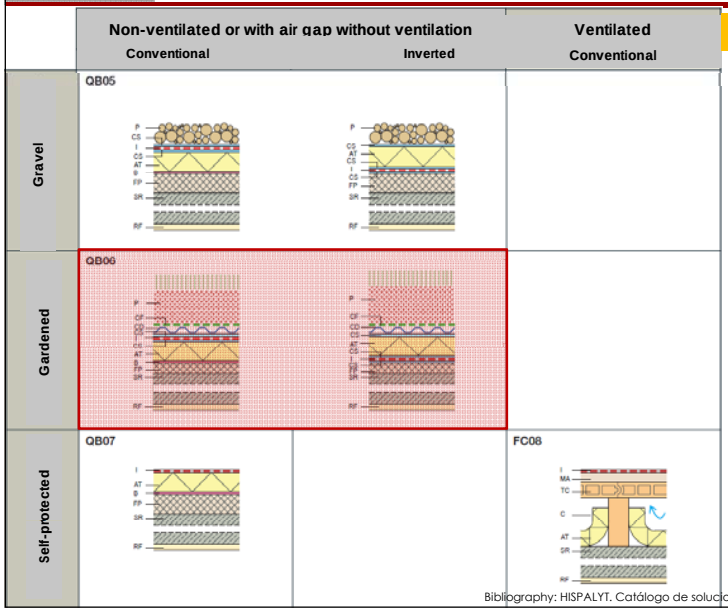
# ICO Types of flat roofs

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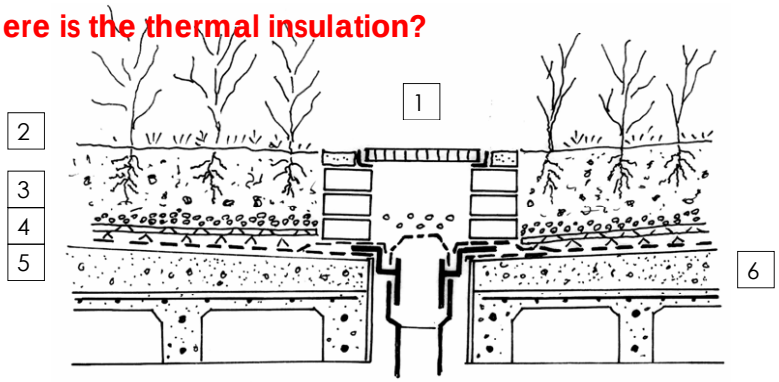
# ICO GARDENED ROOF

**Continuous sheathing?**

**Where is the thermal insulation?**

**"Gardened" roof**. Standard/type section




1) catch basin and drain,
2) vegetal soil layer
3) filtering + draining layer (gravel)
4) separation layer and anti-roots (reinforced geotextile)
5) waterproofing layer
6) slope formation and … properties

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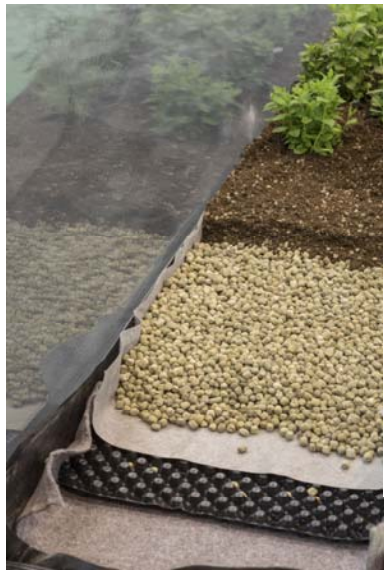
# ICO GARDENED ROOF



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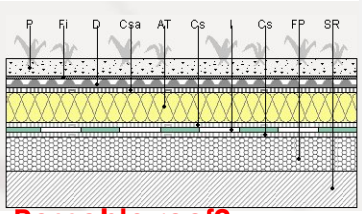
# ICO Gardened roofs….

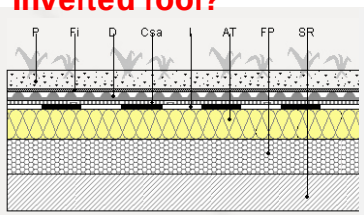



P = Protection (finishing)
Fi = Filtering layer
D = Draining layer
Csa = Separating layer under protection
AT = Thermal insulation
Cs = Separating layer
I = Waterproofing
FP = Slope formation
SR = Resistant support

**Passable roof?**

**Cold roof?**

**Inverted roof?**

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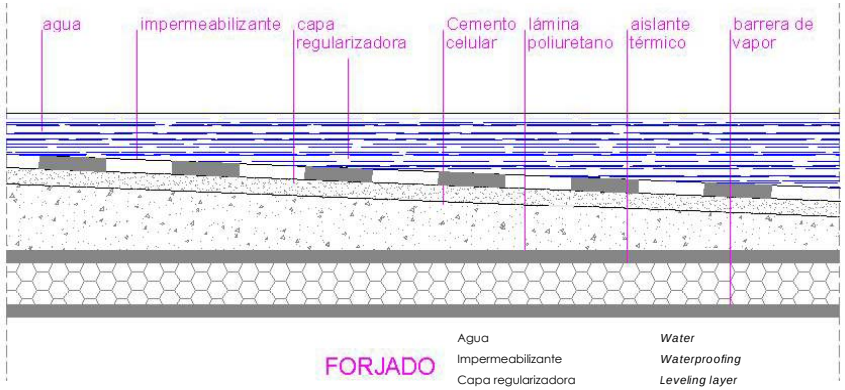
# ICO FLOODED FLAT ROOFS




| | |
|---|---|
| Agua | *Water* |
| Impermeabilizante | *Waterproofing* |
| Capa regularizadora | *Leveling layer* |
| Hormigón celular | *Cellular concrete (slope formation)* |
| Lámina poliuretano | *Polyurethane layer* |
| Aislante térmico | *Thermal insulation* |
| Barrera de Vapor | *Vapour barrier* |
| Forjado | *Floor slab* |

**Passable roof?**

**Cold roof?**

**Inverted roof?**

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# ICO Flooded flat roofs

Contemporary Art Museum, Palma de Mallorca, architect Rafael Moneo.

Flooded roof, lighting with skylights

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# ICO Flooded flat roofs

University of Alicante Auditorium.

Flooded roof, lighting with skylights.

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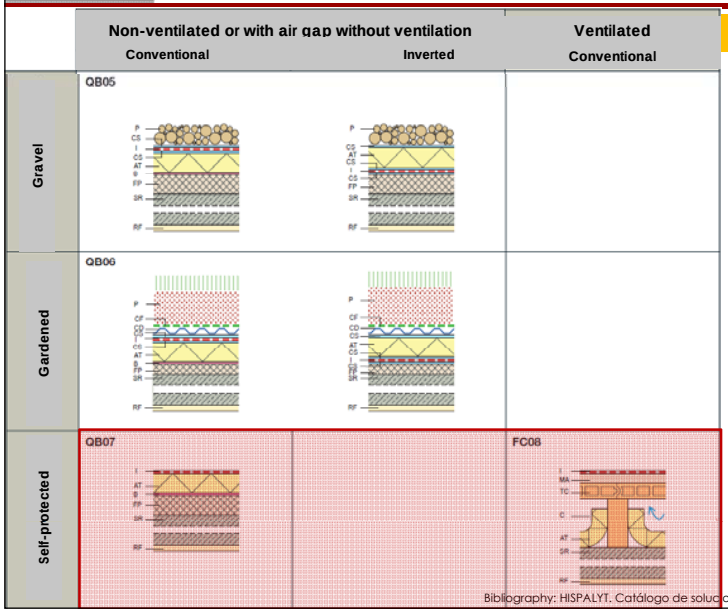
# ICO Types of flat roofs

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# ICO Self-protected

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# ICO Self-protected

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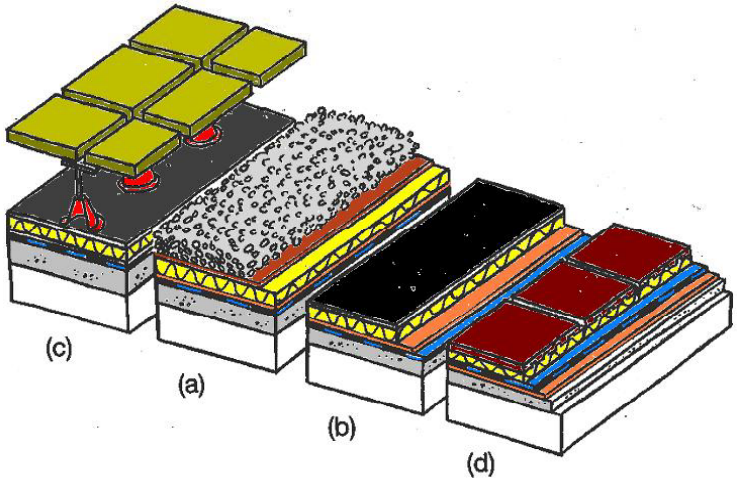
# ICO FLAT ROOF, DIFFERENT FINISHINGS




Different solutions of finishings in flat roofs

Take from the book "Libro Claves del Construir arquitectónico", Autores: González, J.L., Casals, A., Falcones, A.

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**Introduction**
- Roof definition
- Design conditions

**Requirements: CTE Regulation**

**Classification: types of roof** (examples)
- According to its shape or slope
- According to its use
- According to the structural system
- According to its hygrothermal conditions
- According to the thermal insulation position

**Materials**

**Flat roof**
- Types
- Constructive details
- Execution process
- Flat roof and installations

**Pitched roof**
- Types
- Constructive details
- Execution process
- Pitched roof and installations

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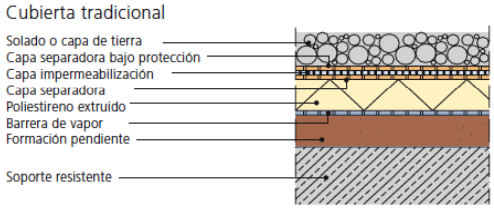
# ICO NON-VENTILATED FLAT ROOFS EXECUTION PROCESS

## CONVENTIONAL ROOF

**Resistant support**

1. **Slope formation**
2. **Vapour barrier**
3. **Thermal insulation**
4. **geotextile**
5. **waterproofing**
6. **Geotextile (pointed protection)**
7. **finishing**

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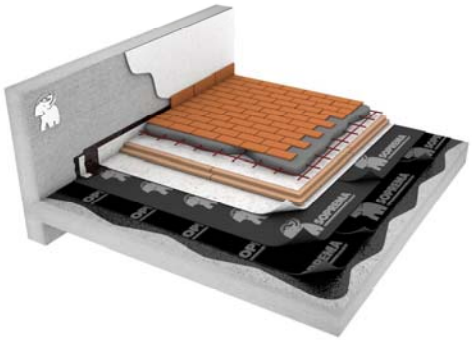
## ICO NON-VENTILATED FLAT ROOFS EXECUTION PROCESS



**INVERTED ROOF**

**Resistant support**

1. **Slope formation**
2. **Waterproofing**
3. **Geotextile (pointed protection)**
4. **Thermal insulation**
5. **geotextile**
6. **finishing**

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## ICO NON-VENTILATED FLAT ROOFS EXECUTION PROCESS

**CONVENTIONAL ROOF**

**Resistant support**

1. **Slope formation**
2. **Vapour barrier**
3. **Thermal insulation**
4. **geotextile**
5. **waterproofing**
6. **Geotextile (pointed protection)**
7. **finishing**

**INVERTED ROOF**

**Resistant support**

1. **Slope formation**
2. **Waterproofing**
3. **Geotextile (pointed protection)**
4. **Thermal insulation**
5. **geotextile**
6. **finishing**

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## ICO WARM FLAT ROOF EXECUTION PROCESS

1. Filling and leveling: formation of slope with expanded clay (arlita) and cement mortar slurry...

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## ICO Flat roofs execution process

1. Slope formation, expansion joints,…

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## Flat roofs execution process

1. Filling with sloping concrete. Detail of the perimeter with expanded polystyrene

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## Flat roofs execution process

Placing the bituminous waterproofing layer, overlapping and applying heat

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ICO

## Flat roofs execution process

Detail of the perimeter, overlap of the sheet.

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ICO

## Flat roofs execution process

Geotextile layer arrangement over the bituminous waterproofing sheet.

Over the geotextile sheet it is placed the thermal insulation and then another geotextile sheet

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# ICO Flat roofs execution process

Thermal insulation arrangement

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# ICO Flat roofs execution process

Finalisation of the roof, installation of the outer protection.

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- Flat roof and installations

**Pitched roof**
- Types
- Constructive details
- Execution process
- Pitched roof and installations

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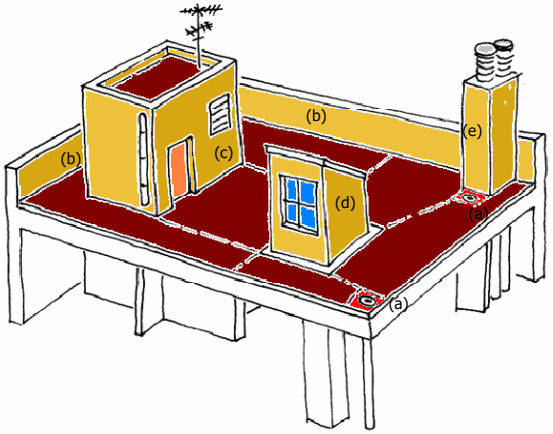
# ICO Vocabulary: flat roofs




a) Drain
b) Parapet
c) Bulkhead
d) Roof-light
e) Ventilation pipe (shunt)

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## ICO The roofs and the installations …

Installation of solar collectors, air conditioning, telecommunications,…

Conditions of resistance, support, impermeability, accessibility,…

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## ICO The roofs and the installations …

AIDICO building roof, Paterna (Valencia).

Detail of the solar installation support

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## ICO The roofs and the installations …

**Filtering tile** with insulation placed over the waterproofing layer in order to prevent the direct contact of the installations.

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## Cubiertas planas

Cubiertas transitables (1-5%)… baldosas.
Cubiertas no transitables (1-15%)… grava, inundadas

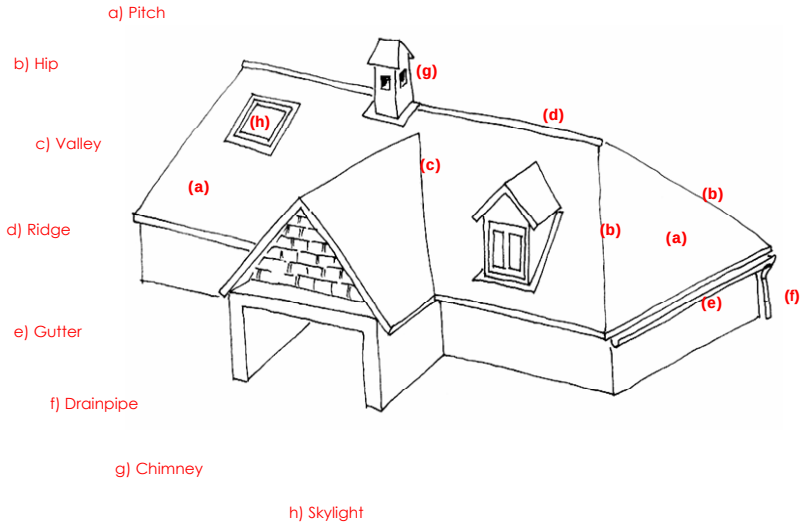
## Cubiertas inclinadas

Uso del espacio "bajo cubierta",
Con buhardillas y mansardas





# ICO Vocabulary: pitched roofs

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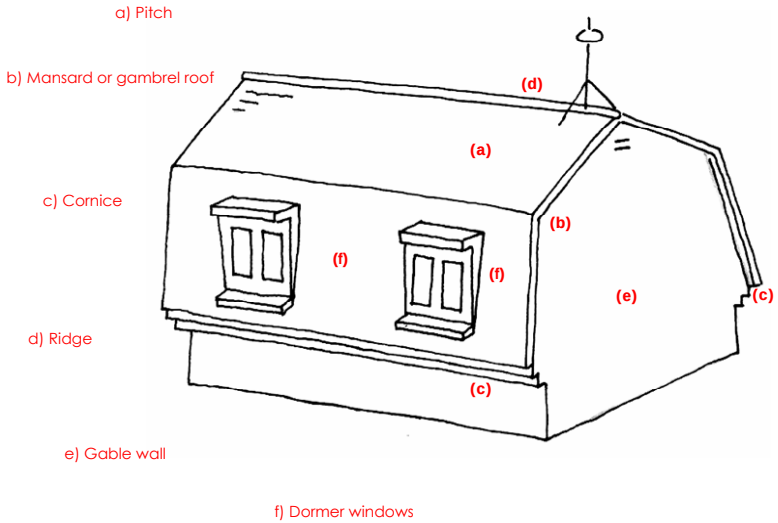
# ICO Vocabulary: pitched roofs

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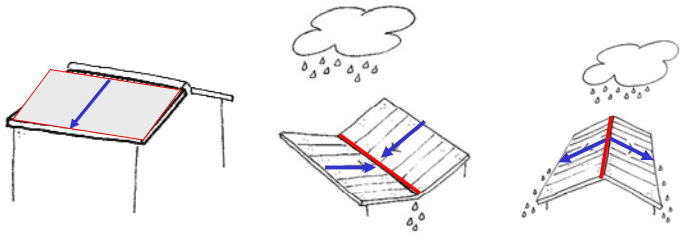
# ICO Vocabulary: pitched roofs

- Pitch: Inclined plane that defines the roof.
- Intersection of two pitches.
  - Valley, in v-shaped (concave)
  - Hip in inverted v-shaped (convex)



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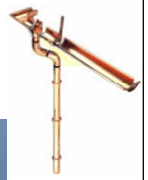
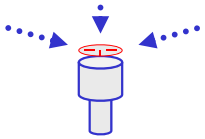
# ICO Vocabulary: pitched roofs

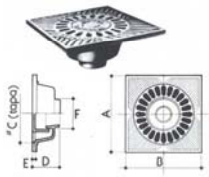
- Pitch: Roof pitch, as a % or in degrees

- Drain: Hollow where water is collected
- Gargoyle: small evacuation pipe to the exterior
- Gutter: rainwater collection system for a roof. It can be hidden or "box", and hanged or external



- Drain pipe: vertical pipe for water drainage





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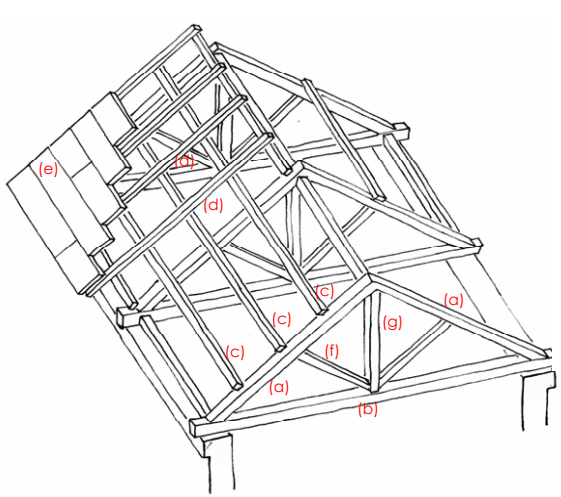
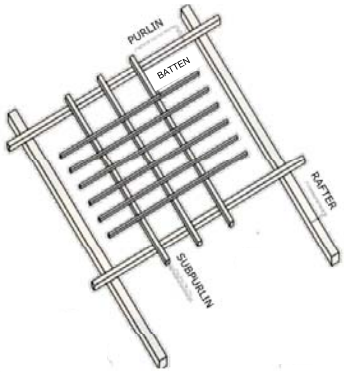
# ICO Vocabulary. Pitched roofs. Structural frames: trusses.




a) Rafter
b) Tie beam
c) Purlins
d) Subpurlin
e) Roof board
f) Raking shore
g) King post

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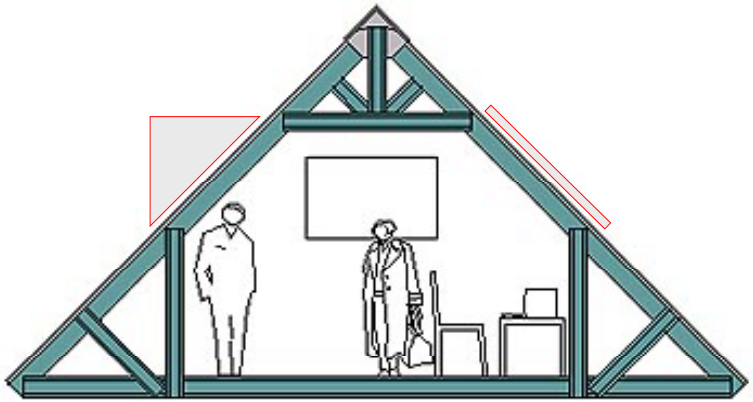
# ICO Pitched roofs. Use of the space under the roof



Limitations in terms of **use in space under the roof**, structure, headroom, lighting and ventilation

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# ICO Pitched roofs. Use of the space under the roof

Formation of **dormers** on traditional roofs.

Comillas (Asturias)

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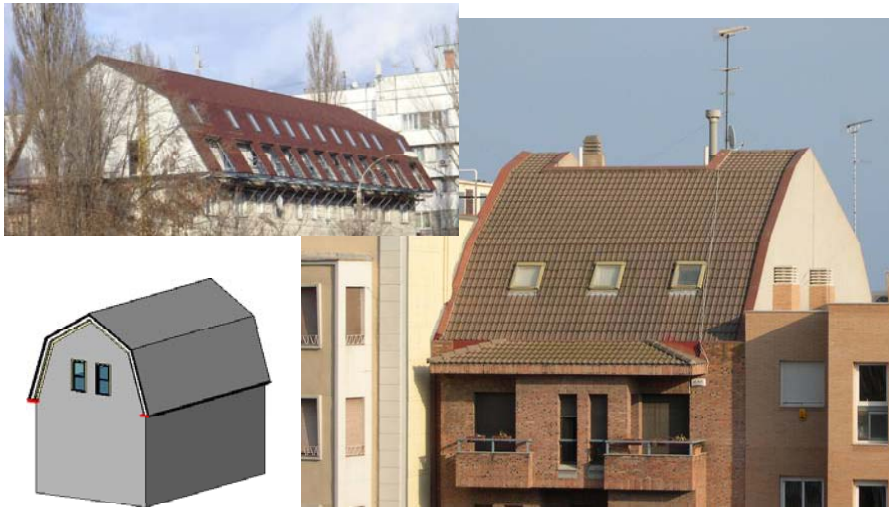
# ICO Pitched roofs. Use of the space under the roof



Mansard" roof with ceramic roof tiles and windows on its plane

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# ICO Pitched roofs. Use of the space under the roof

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# ICO Pitched roofs. Use of the space under the roof

Traditional sloping roof with ceramic tiles and dormers

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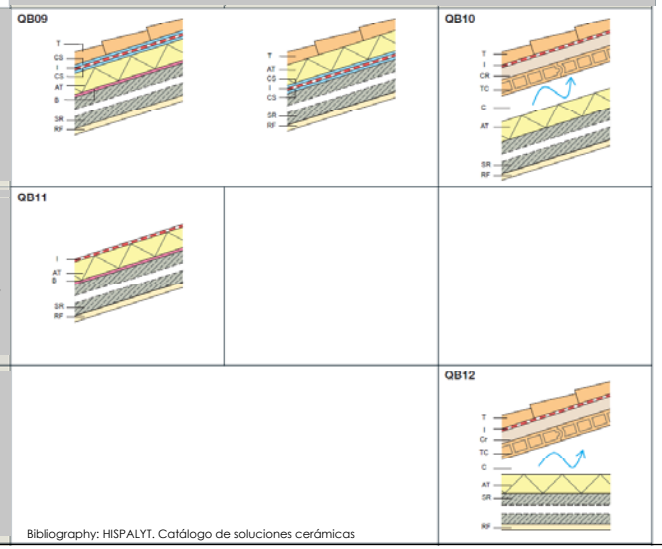
# ICO Types of pitched roofs

| | | Non-ventilated or with air gap without ventilation | | Ventilated |
|---|---|---|---|---|
| | | Conventional | Inverted | Conventional |
| Inclined resistant support | Tile roof | QB09 | | QB10 |
| | Self-protection | QB11 | | |
| Horizontal resistant support | Tile roof | | | QB12 |



T = Tile (roof)
CS = Separating layer
CR = Leveling layer
TC = Ceramic board
C = Chamber / air gap
I = Waterproofing
AT = Thermal insulation
B = Vapour barrier
FP = Slope formation
SR = Resistant support
RF = Underside coating

Bibliography: HISPALYT. Catálogo de soluciones cerámicas

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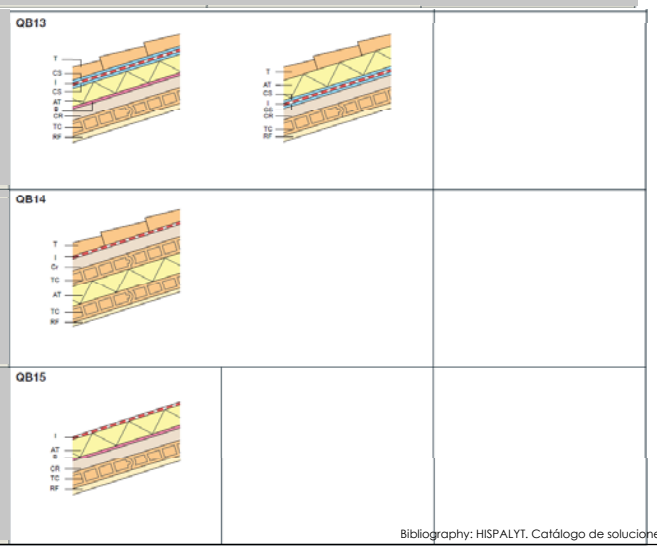
# ICO Types of pitched roofs

| | | Non-ventilated or with air gap without ventilation | | Ventilated |
|---|---|---|---|---|
| | | Conventional | Inverted | Conventional |
| With ceramic board supported by beams or trusses | Tile roof on simple ceramic board | QB13 | | |
| | Tile roof on double ceramic board | QB14 | | |
| | Self-protection | QB15 | | |



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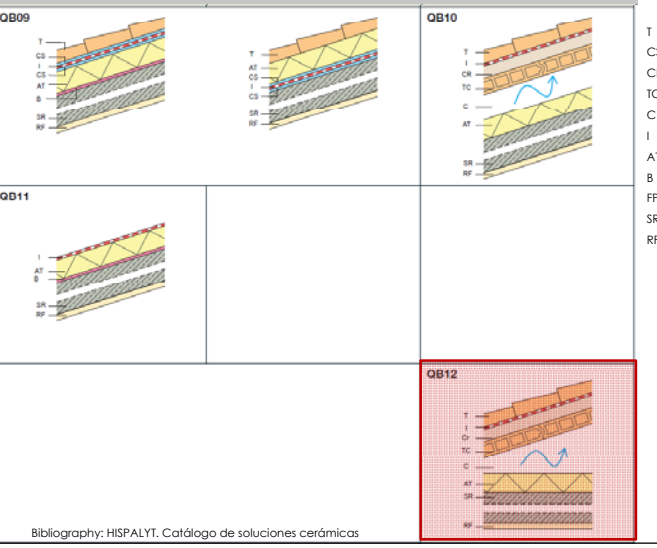
| Horizontal resistant support | Tile roof | | | QB12 |



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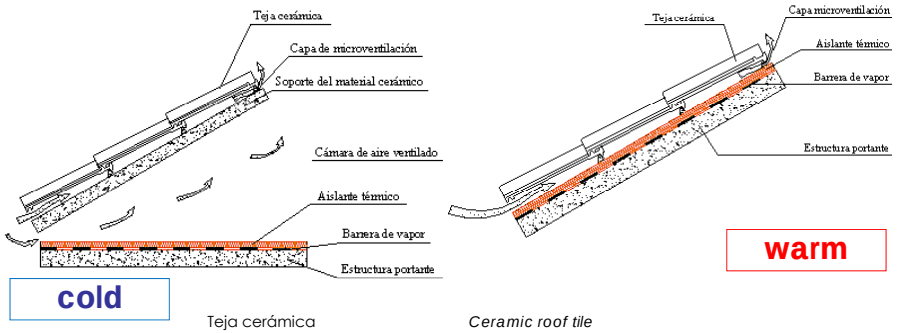
# ICO CONSTRUCTIVE DETAILS: pitched roofs

**What element is missing? And, where would we place it?**




| | |
|---|---|
| Teja cerámica | *Ceramic roof tile* |
| Capa de microventilación | *Micro-ventilation layer* |
| Soporte de material cerámico | *Support / base of ceramic material* |
| Cámara de aire ventilado | *Ventilated chamber / air gap* |
| Aislante térmico | *Thermal insulation* |
| Barrera de vapor | *Vapour barrier* |
| Estructura portante | *Resistant support* |

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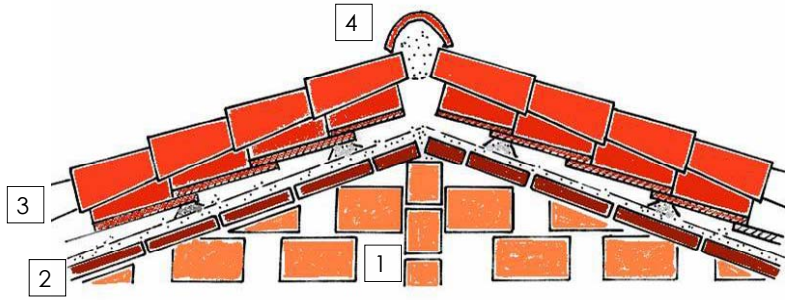
# ICO CONSTRUCTIVE DETAIL: cold (ventilated) pitched roof

Pitched roof constructive detail




1) Lightweight partition walls
2) Ceramic board
3) Ridge and Eave roof tiles
4) Ridge

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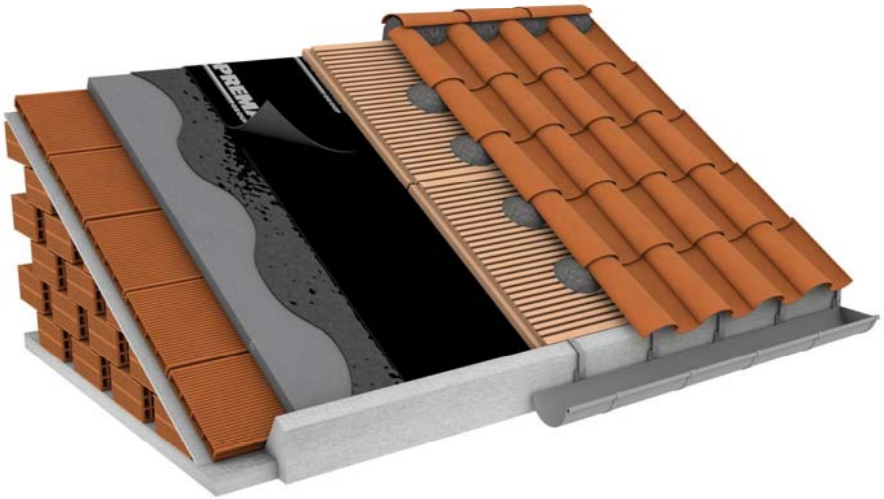
# ICO CONSTRUCTIVE DETAIL: cold (ventilated) pitched roof



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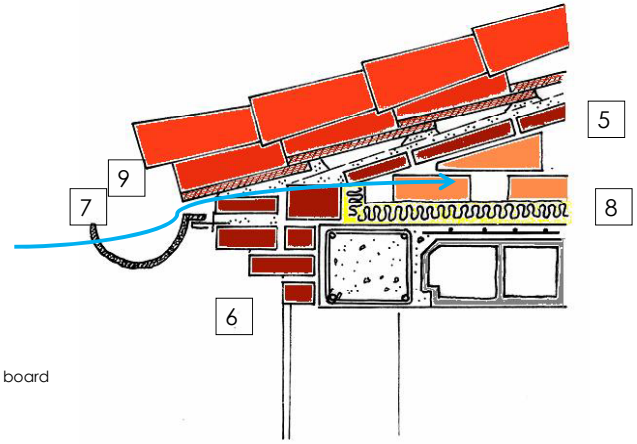
# ICO CONSTRUCTIVE DETAIL: cold (ventilated) pitched roof

Pitched roof constructive detail




5) Ceramic board
6) Cornice
7) Gutter
8) Thermal insulation
9) Front tile

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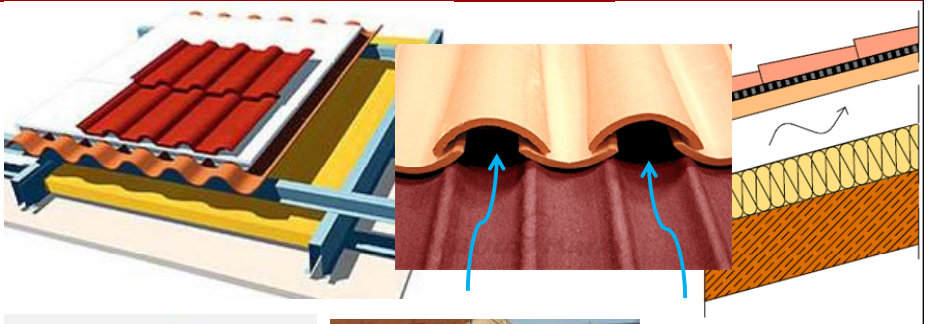
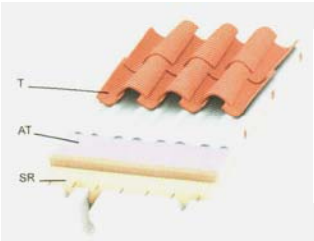
# ICO CONSTRUCTIVE DETAIL: cold (ventilated) pitched roof





**T:** Tiles (roof)
**I:** Waterproofing layer
**TS:** Tablero soporte de madera
**C:** Ventilated chamber
**A:** Thermal insulation
**SR:** Resistant support

Detail of commercial solution

Roof on battens with interposition of several layers of different materials

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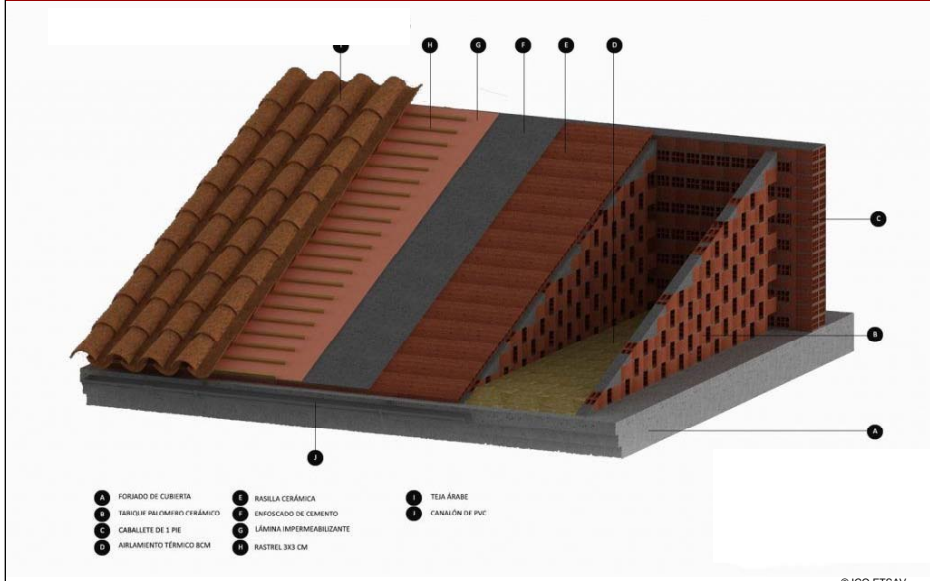
# ICO CONSTRUCTIVE DETAIL: cold (ventilated) pitched roof

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# ICO EXECUTION PROCESS: COLD (VENTILATED) PITCHED ROOFS

Lightweight partition walls execution

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## ICO EXECUTION PROCESS: COLD (VENTILATED) PITCHED ROOFS

Lightweight partition walls execution

Using: Pole, rope, gypsum…

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## ICO EXECUTION PROCESS: COLD (VENTILATED) PITCHED ROOFS

**On which element does the lightweight partition wall rest?**

Arrangement of thermal insulation

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## ICO EXECUTION PROCESS: COLD (VENTILATED) PITCHED ROOFS

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## ICO EXECUTION PROCESS: COLD (VENTILATED) PITCHED ROOFS

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## ICO Execution process: pitched roofs

Ceramic board

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## ICO Execution process: pitched roofs

Leveling mortar

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## ICO EXECUTION PROCESS: COLD (VENTILATED) PITCHED ROOFS

Lightweight partition wall, ceramic board, and leveling mortar

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## ICO Execution process: pitched roofs

Roof in execution: arrangement of curved ceramic tile,

Single-family house, Picassent (Valencia)

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# ICO EXECUTION DETAILS: COLD OR VENTILATED PITCHED ROOFS.

ON
INCLINED
FLOOR SLAB

**Continuous sheathing?**

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# ICO EXECUTION PROCESS: COLD (VENTILATED) PITCHED ROOFS

Roof in execution: arrangement of mix ceramic tile

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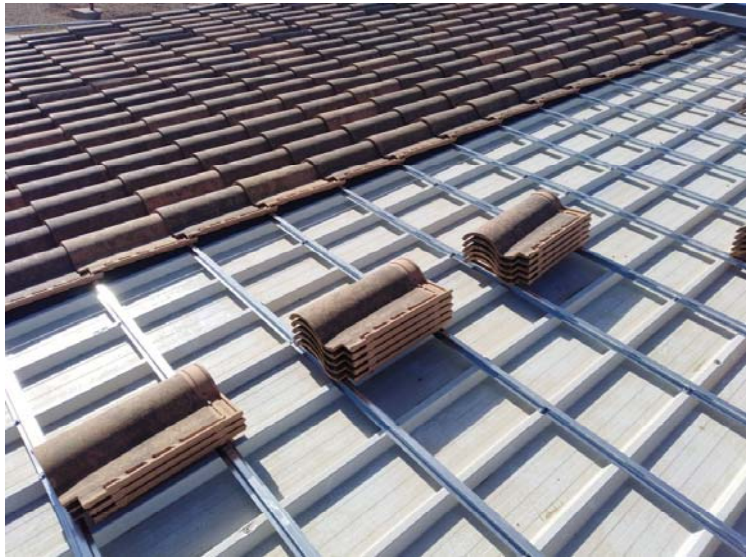
# ICO EXECUTION PROCESS: COLD (VENTILATED) PITCHED ROOFS



Roof in execution: arrangement of mix ceramic tile

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# ICO EXECUTION PROCESS: COLD (VENTILATED) PITCHED ROOFS

Roof in execution: arrangement of curva ceramic tile

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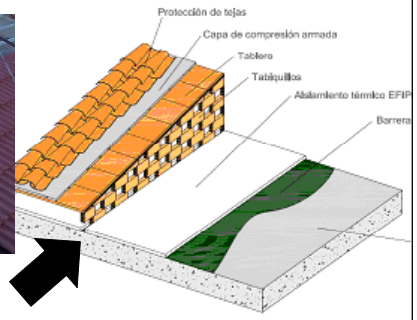
# ICO EXECUTION PROCESS: COLD (VENTILATED) PITCHED ROOFS

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# ICO EXECUTION PROCESS OF INDUSTRIALIZED ROOFS

**PASSABLE ROOF?**

**INVERTED ROOF?**

**COLD ROOF?**

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# ICO Lighting elements

ETS de Arquitectura de Valencia roof.
Skylights

Roof with skylight

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## Chimney or ventilation ducts

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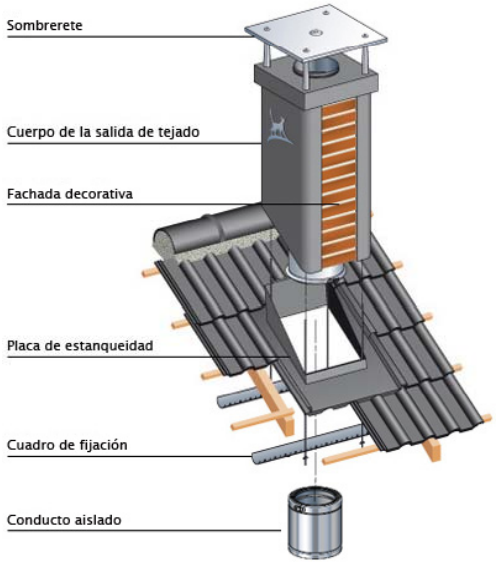
## Chimney or ventilation ducts

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## Chimney or ventilation ducts, and skylights

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## Solar panels

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